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MECHANICAL PROPERTIES OF MILD STEEL UNDER ARC WELDING AND GAS WELDING: A COMPREHENSIVE ANALYSIS

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ABSTRACT

This article narrates the strength aspects of the mild steel specimen widely preferred for light structural applications. This unhardened mild steel specimen is welded using arc and gas welding and both specimens are subjected to transverse testing, hardness testing, and tensile testing based on these reports we have concluded the specimen that offers high strength.

Keywords: Arc welding, Gas welding, Tensile test, Hardness test, Transverse test

I.INTRODUCTION

When joining metal parts together, two of the most popular welding techniques are arc welding and gas welding. Whereas gas welding uses a flame, arc welding produces heat via an electric arc. Mild steel may be welded using either method, but which method yields stronger welds? Low carbon content carbon steel is referred to as mild steel. It is a widely utilized and adaptable material in a variety of industries, such as manufacturing, construction, and automotive. In many applications, the strength of the weld is a crucial consideration. High loads and pressures can be applied to a strong weld without it failing. As a result, selecting the appropriate welding method for the task is crucial. This study compares mild steel specimens welded by arc and gas, emphasizing the welds' tensile strength, transverse strength, and hardness. A material's tensile strength is its capacity to withstand tearing. The ability of a material to withstand breaking perpendicular to the direction of the force is known as transverse strength. The resistance of a material to indentation is known as its hardness. Except for the shielding gas employed, the two welding techniques were performed on the same mild steel specimens and welding conditions. While gas welding was done using a gas metal arc welding (GMAW) [1] method with a carbon dioxide shielding gas, arc welding was done using a shielded metal arc welding (SMAW) [2] process with a flux-covered electrode. The specimens underwent tensile, transverse, and hardness tests following the welding process. The strongest welds were made by a certain welding procedure, which was determined by comparing the test results. Engineers and technicians can choose the best welding procedure for their particular application with the aid of the study's conclusions.[3]

2.MATERIALS AND METHODS

Fig.1 Specimen before testing

We utilized an unhardened mild steel specimen (Fig.1) in this technique since it is a moderately ductile and flexible material that can be shaped into a variety of shapes. The mild steel specimen was selected for its high ductility, low carbon content, low toughness, and ease of welding. It is utilized in light-structured applications. Because of its superior machinability, it finds usage in a wide range of applications. Because of its resistance to corrosion and superior flowability, it may be exposed to a variety of welding operations more easily.

Chemical Composition

- Iron (Fe): 98.8-99.3%
- Carbon (C): 0.05-0.25%
- Silicon (Si): 0.15-0.35%
- Sulfur (S): Maximum 0.05%
- Phosphorus (P): Maximum 0.05%

2.2Hardness Test

Fig.2 Rockwell Hardness Testing Machine

The hardness test is performed using a Rockwell hardness tester (Fig.2), since it is a mild steel specimen (Fig.3) the indenter chosen is 1/16 ball Indenter, and a load of 100kgf and B scale is chosen as per the Instruction.

Fig.3 Specimen subjected to hardness test with indentation mark

2.2. Transverse test

As a crucial mechanical assessment for welded specimens (Fig.4), the transverse tensile test measures the specimens' resilience and malleability in response to tensile forces that are applied perpendicular to the weld. In the context of Welding Procedure Qualification (WPQ), this testing process is essential because it serves as a strict benchmark to ensure that welds strictly conform to predetermined standards for tensile strength, yield strength, and elongation. Within the context of quality control (QC) testing, the transverse tensile test plays a pivotal role in verifying the consistency of weld quality throughout the production process by methodically examining randomly chosen welds to make sure they meet the necessary tensile properties. Furthermore, the test works wonders in the field of research and development (R&D), acting as a cornerstone for the assessment of cutting-edge welding.

Fig.4 Specimen subjected to transverse Loading

2.3 Tensile Testing

A basic test in materials science, tensile testing determines a material's tensile strength, yield strength, modulus of elasticity, elongation, and area reduction. Using a universal testing machine (UTM), a sample is subjected to controlled tension until failure. Tensile testing is a powerful tool for characterizing and choosing materials for a wide range of applications because it is a reasonably easy and affordable test that yields a wealth of information about a material's mechanical properties (Fig.5). It is employed in figuring out the materials' modulus of rigidity, yield strength, tensile strength, elongation, and area reduction. Tensile strength is found to decrease with increases in voltage, welding current; however, tensile strength also increases with an increase in welding speed. The elongation case is identical to the tensile strength case.[4]

Fig.5 Specimen subjected to tensile test

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3.RESULTS AND DISCUSSION

3.1.Hardness Test

Based on the findings of the Rockwell hardness test, which was performed on two mild steel specimens that were subjected to both gas and arc welding, three tests were conducted on each specimen, and it is evident from comparing the mean values of the two welding processes that arc welding provides a stronger and more durable weld than gas welding because it uses more filler material. when the voltage and welding current increase, tensile strength decreases, but when welding speed increases, the tensile strength also increases. In the case of elongation is also the same as tensile strength.[5]

Table 1 Hardness

Welding	Load	Scale	I	II	III	Mean
Arc	100Kgf	B	90	91	91.5	90.83
Gas	100Kgf	B	73	61	67	67

3.2.Transverse Test

3.2.1. Arc Welding

The arc welding transverse test values that you have provided indicate that the welded joint has a peak load of 2.500 KN and a transverse strength of 1000.000 N/mm2 (Fig.6). This means that the weld can withstand a force of 2.500 KN (approximately 2.5 tons) before failing and that the material in the weld is strong enough to withstand a stress of 1000.000 N/mm2 before failing.[6]

These are very good values for an arc-welded joint. The peak load is well above the requirements for most applications, and the transverse strength is excellent. This indicates that the weld is of high quality and is likely to be very reliable.

Peak load: The maximum force that the weld can withstand before failing. The peak load is measured in units of force, such as KN (kilonewtons) or pounds (lbs).

Transverse strength: The strength of the weld in the direction perpendicular to the weld line. The transverse strength is measured in units of stress, such as N/mm2 (megapascals) or psi (pounds per square inch).

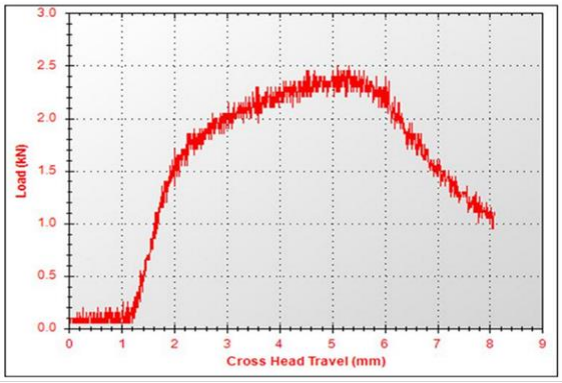

Fig.6 Cross head travel Vs Load (Arc weld)

3.2.2 Gas Welding

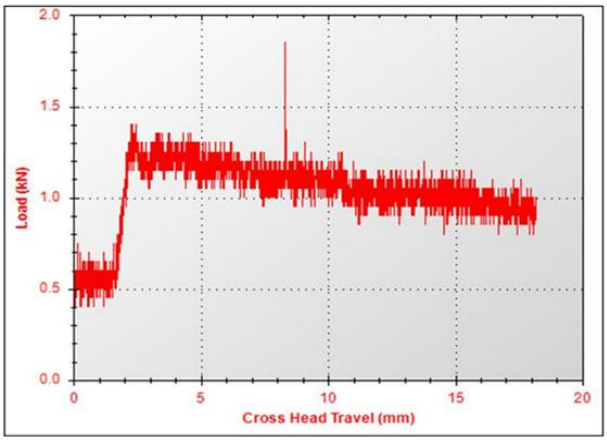

Fig.7 Cross head travel Vs Load (Gas weld)

The arc welding transverse test values that you have provided indicate that the welded joint has a peak load of 1.850 KN and a transverse strength of 740.000 N/mm2 (Fig.7). This means that the weld can withstand a force of 1.850 KN (approximately 1.85 tons) before failing and that the material in the weld is strong enough to withstand a stress of 740.000 N/mm2 before failing.

From the above test results we could conclude that arc welding offers higher transverse strength than gas welding.[7]

3.3.Tensile Test

3.3.1. Arc Welding

The welded joint has an elongation of 1.82%, a tensile strength of 383.333 N/mm2, and a yield stress of 306.25 N/mm2, according to the arc welding transverse test values you have provided [8]. The stress at which a material starts to undergo plastic deformation is known as yield stress. This indicates that after the stress is released, the material won't revert to its initial form. The highest stress a material can bear before failing in tension is known

as its tensile strength. The amount of deformation in a material before it breaks under tension is called elongation. It is given as a percentage of the material's initial length. The range that is appropriate for arc welded joints includes all of these values. Both the tensile strength and yield stress are high, which [9]

3.3.2. Gas Welding

Based on the tensile test results, the mild steel specimen undergone gas welding has a yield stress of 251.042 N/mm2, a tensile strength of 314.236 N/mm2, and an elongation of 2.73%. These results indicate that the specimen has good strength and ductility. The yield stress is the point at which the specimen begins to deform plastically, and the tensile strength is the maximum stress the specimen can withstand before failure. The elongation is a measure of how much the specimen can deform plastically before failure. The higher the yield stress and tensile strength, the stronger the specimen. The higher the elongation, the more ductile the specimen. Welding current, welding speed, arc voltage, type of shielding gas, gas flow rate, wire feed rate, the diameter of the electrode, etc. are the important control parameters of the Metal Inert Gas Welding process.[10]

4.CONCLUSION

Ultimately, the outcomes of extensive hardness testing, tensile testing, and transverse testing emphasize the greater strength and significant advantages that arc welding provides over gas welding. The results of the hardness tests show that the arc-welded joints have a higher degree of material hardness, which is suggestive of improved resistance to wear and deformation. This increased hardness, which the tensile tests confirm, indicates an exceptional tensile strength, confirming the weld's ability to bear applied forces without cracking.

Moreover, the transverse tests reliably show the robustness of arc-welded specimens by simulating real-world stresses perpendicular to the weld. The enhanced ductility and resistance to fracture of arc-welded joints under transverse tensile forces highlights their structural integrity and dependability in various applications.

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